Externalities: regulators see benefits; utilities cite cost

CHICAGO—How much will utility customers pay in higher electric bills for perceived societal benefits?

While that question is central to environmental regulation, it can be particularly sensitive when determining the source, type, or fuel for new generating capacity.

This is one of the principal dilemmas behind environmental externalities, or adders, identified at a session of the American Power Conference, held here April 13-15.

Status of Recognizing Externalities

Under Development
– Connecticut
– Georgia
– Michigan
– Minnesota
– Oregon
Monetized
– California
– Massachusetts
– Nevada
– New Jersey
– New York
Points Awarded or % Adjustment
– Colorado
– Iowa
– Vermont
– Wisconsin

Source: Energy Management Associates

A tool to promote specific choices

Externalities are regulatory additions or subtractions made to the estimated cost of supply or demand-side options during the planning process. Regulators increasingly are using them to influence utilities' decisions, mostly away from fossil fuels, usually coal. Externalities can also promote options such as renewables, or conservation, often within an integrated-resource-planning or least-cost-planning process.

Michael Holstein, with Atlanta-based Energy Management Associates, used an externalities definition from Pace University Center for Environmental Studies: "costs which occur after all government-imposed environmental standards and regulations are met."

He described the kinds of externalities now in place, or under development, in various states (see table). At least five states have externality programs under development, while nine more have provisions in place.

Percentage adjustment

Some states award a percentage adjustment or points to influence choices in planning. Wisconsin regulators, said Holstein, add 15 percent to net present value of revenue requirements for fossil-fueled generation when compared to demand-side options or renewables.

Another way is to "monetize" the process by adding cents per kWh to some options.

This can be based on an estimated cost of controlling the pollutant, or some quantification of an environmental damage assessment. Externalities included are NOx, SOx, CO_2, VOCs, particulates, CH_4, N_2O, and water and land use. Values assigned to each vary widely.

NOx damages: $27,676/ton

According to the Electric Power Research Institute, assigned values for NOx range from a high of $27,676 per ton in California, down to $101 per ton in the east portion of Bonneville Power Administration. Per ton values for CO_2 are $7-107; SO_2, $1274-$27,436.

The bar chart shows residual environmental costs attached to coal, pressurized-fluidized bed and combined-cycle generation by New York, Massachusetts, and Nevada, in cents per kilowatthour.

The Department of Energy and others plan to determine full life-cycle costs of various fuels, which, some argue, would give a more complete and fair assessment of environmental costs attached to generating options.

Trends in externalities within least-cost planning include emphasis of conservation over load-management programs, gas over coal, and promotion of renewables, Holstein said.

Externalities can cause problems, he said, including creating more pollution.

A simple adder on baseload coal generation might prevent construction of a baseload unit that could displace older, less efficient plants, he explained. Dispatch of generation might be a logical extension of environmental externality costs, said Holstein.

When externalities increase costs, some customers may "vote with their feet," and move, or expand elsewhere, he said.

Also, "alternatives may exist with greater environmental benefits, at a lower cost," Holstein said. These might get passed over in an IRP process with externalities.

Holstein emphasized uncertainties.

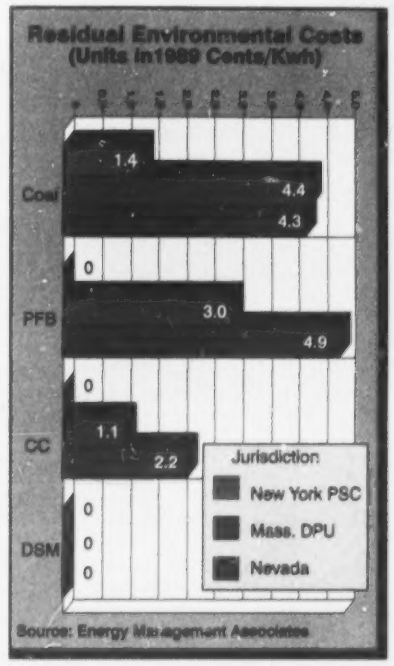
"Utilities have the enviable position of planning based on predicted environmental regulation, and if they're wrong they get penalized for it."

Other developments

In other externality developments:

- Electric Power Research Institute started the "Environmental Externalities Information Clearinghouse" on the EPRINET electronic bulletin board for members.
- Recent planning goals outlined by the California Public Utility Commission said "Monetary value is given after all mandatory pollution abatement measures have been implemented. A negative value is put on residual emissions and that negative value increases the total cost of resources with high levels of residual emissions."
- The National Rural Electric Cooperative Association at its 50th Annual meeting passed a resolution that said externality costs should be scientifically derived, realistic, equitable and not speculative.

Addressing California regulators directly in later comments, the NRECA said that artificially inflating the cost of coal-fired electricity might be economically and environmentally counterproductive.



Federal gov't awards utility wildlife efforts

WASHINGTON—Kansas Power & Light Co. won the Corporate Wildlife Stewardship Award from the U.S. Department of Interior's Fish and Wildlife reservce.

KPL is the third recipient, and the first electric utility, to receive the annual award. The award cites corporations for enhancing the environment and outstanding contributions to conservation and wildlife management.

KPL, now operating under the name Western Resources, established a task force to make environmental protection "a part of day-to-day operations," said Fish and Wildlife Service Director John Turner in making the award.

The company's efforts include:

- Transformation and restoration of wetland areas with wildlife departments of Oklahoma and Kansas.
- Construction of roosts for large birds and an eagle rehabilitation flight pen.
- Extensive recycling programs for tree clippings, fly ash, scrap metal, tires, oil, batteries, and other wastes.

Two KPL utility workers survey Nowata wetlands, a former, 1100-acre oil and gas field that the company helped transform along the Verdigris River in Oklahoma.

Syncoal project starts up early

COLSTRIP, MT—The Rosebud Syncoal Partnership project started up in late March, ahead of schedule. The goal of this Clean Coal Technology project is to demonstrate an advanced thermal drying and physical coal-cleaning process that can reduce moisture and raise heat content of low-rank subbituminous and lignite coals.

The plant, located next to Western Energy's Rosebud Mine, was originally scheduled to take 18 months to build and bring into operation. Instead, the process was completed in 10 months, with much of the work done during the winter.

Testing begins

The partnership began sending Powder River Basin coal through the plant for cold-flow testing on Jan. 30. This was followed with short-duration production runs. Gradual production of the syncoal product began at the "start-up" in late March. The plant was expected to reach full operation in late spring.

In continuous, full operation the facility will produce 1000 tons/day (or 300,000 tons/year) of upgraded solid fuel. It is only one-tenth the size of a full commercial-scale plant, even though its processing equipment is commercial-scale.

What it does

The syncoal process reduces moisture content of the coal from 25 percent to as low as 1 percent and raises the heating value from about 8600 Btu/lb up to 11,700 Btu/lb.

The fuel's sulfur content is only 0.3 percent, which means it can be burned in many existing coal-fired plants to meet emissions standards of the Clean Air Act Amendments of 1990.

The demonstration plant is integrated with a unit train loading facility and a stockpile that can hold up to 90,000 tons of coal.

Shipments begin

The first 5000-ton shipment was scheduled for Northern States Power Co.'s Riverside plant near Minneapolis where it will be used for an initial test burn. Dairyland Power Cooperative committed to test burn the next 5000 tons at its Alma Station about 20 miles south of Eau Claire, WI.

Rosebud Syncoal is working on plans with other utilities for test burns.

Total project cost is $69 million, with the Department of Energy providing half of that amount.

Acquisition update: Colorado, New England transactions are done

In utility merger and acquisition news, six utility companies reported transactions.

Three utilities completed acquisition of Colorado-Ute Electric Association, which had filed for Chapter 11 bankruptcy protection.

The transaction totalled more than $800 million.

As previously reported, three utilities split customers and assets: Public Service Co. of Colorado, PacifiCorp, and Tri-State Generation and Transmission Association (*EL&P*, 8/91, p.1).

In New England

In an unrelated transaction, UNITIL Corp., a utility holding company based in Bedford, NH, acquired Fitchburg Gas and Electric Light Co., of Fitchburg, MA.

COMMENTARY

What deregulation?

If the electric utility industry is in the process of being deregulated then why is the heavy hand of the regulator heavier than ever and likely to get even heavier in the future?

One answer is that while some regulators at the federal level, mainly at the Federal Energy Regulatory Commission, are moving the industry toward market pricing, competition, and deregulation, most of the rest of the regulatory community is clamping down.

At the state level, in particular, utility regulation is being increased. State public utility commissions are becoming more involved in the utility planning process and, in many cases, mandating what the plan must be, based on political considerations.

State and federal regulators are moving in opposite directions. Ohio PUC Commissioner Ashley Brown, a leading state regulator, told the American Power Conference that while this difference is "philosophically irreconcilable" it is a reality that will probably continue. FERC will concentrate on regulating bulk power supply where more competition is possible, while state regulators focus on the rest of the utility business.

However, that leaves most of the utility/regulator interface in the state realm where the strong hand of government is increasing. State regulators are not limited to T&D operations, customer relations, and retail prices. They are also intimately involved in bulk power supply through the planning and approval processes and this involvement is increasing. More and more states are forcing utilities to do integrated resource planning or least-cost planning.

The purpose of IRP and LCP is to inject a bias in utility planning against supply-side alternatives—the new euphemism for power plants. State regulators who don't like power plants are forcing utilities to adopt other choices in their plans. A favorite new technique for achieving this is to dictate to utilities how they must internalize "externalities" in their evaluation of alternatives. Externalities are environmental costs that are not directly quantifiable, such as estimated health costs to society caused by allowed emissions or an estimated cost for an unregulated "pollutant" such as carbon dioxide. When regulator-mandated external cost estimates are added to the actual cost of a coal-fired power plant, for example, then other alternatives such as demand-side management turn out to be the least-cost choice.

There's a danger that regulations like this will skew planning too much in favor of expensive conservation or demand-side-management programs, warned David Porter, senior vice president of Wisconsin Electric Power, at the American Power Conference. There's a danger of "least cost at any cost," said Porter. He noted that his company has been involved in IRP for the past 10 years and that it's here to stay, but he pleaded for reasonableness. DSM, said Porter, cannot be expected to reduce base load growth more than about 10 percent. IRP goals of 50 percent or more are unreasonable, he said.

The rest of the world is moving away from central planning. Tightly regulated, state-owned electric utilities are being privatized and deregulated. But not here. The heavy hand is getting heavier.

Robert Smock, Editorial Director

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Gap widens between most and least expensive summer electric bills

Twelve Most Expensive Companies

Company Name	State	Avg. Cost Cents/kWh	Summer 1991 National Rank
Long Island Lighting Co.	New York	$0.157	1
Consolidated Edison Co. of N.Y.	New York	$0.150	2
Philadelphia Electric Co.	Pennsylvania	$0.147	3
Pennsylvania Power Co.	Pennsylvania	$0.144	4
Duquesne Light Co.	Pennsylvania	$0.141	5
Orange & Rockland Utilities, Inc.	New York	$0.138	6
Hawaii Electric Light Co.	Hawaii	$0.137	7
Cleveland Elec. Illuminating	Ohio	$0.137	8
Commonwealth Electric Co.	Massachusetts	$0.137	9
Nantucket Electric Co.	Massachusetts	$0.136	10
Citizens Utilities – Kauai Div.	Hawaii	$0.131	11
Toledo Edison	Ohio	$0.129	12

Twelve Least Expensive Companies

Company Name	State	Avg. Cost Cents/kWh	Summer 1991 National Rank
Washington Water Power Co.	Idaho	$0.042	192
Washington Water Power Co.	Washington	$0.043	191
Pacific Power & Light Co.	Washington	$0.044	190
Idaho Power Co.	Idaho	$0.047	189
Idaho Power Co.	Oregon	$0.047	188
Portland General Elec. Co.	Oregon	$0.047	187
Pacific Power & Light Co.	Montana	$0.048	186
Kentucky Utilities Co.	Kentucky	$0.051	185
Puget Sound Power & Light Co.	Washington	$0.054	184
Montana Power Co.	Montana	$0.054	183
Minnesota Power & Light Co.	Minnesota	$0.055	182
Pacific Power & Light Co.	Oregon	$0.055	181

Source: National Association of Regulatory Utility Commissioners

Some residents paid 373 percent more than others for their electric bills last summer, according to a survey by the National Association of Regulatory Utility Commissioners. Washington Water Power Co. residential customers in Lewiston, ID, paid the least for their 1991 summer bills, 4.2 cents per kWh, while customers of Long Island Lighting Co. in Long Beach, NY, paid the most, 15.7 cents per kWh.

NARUC's national survey showed that the gap between least and most expensive summer utility rates widened from 1990 to 1991. A 350-percent gap in 1990 increased to 373 percent in 1991, according to NARUC.

The average cost of electricity across the nation last summer was 8.9 cents per kWh. Summer residential bills increased 3.5 percent from 1990 to 1991.

In its report, NARUC notes that simple kWh comparisons may not accurately reflect the true cost of electricity to the retail customer, due to demand-side management programs now in place.

NEWS BRIEFS

JILL MINNER, Assistant Editor

Project to produce wire from superconductors

The Department of Energy's Argonne National Laboratory said it is working on a research project with Intermagnetics General Corp. (IGC) to manufacture practical lengths of wire from high-temperature superconductors. "At the end of the project we expect to achieve practical superconducting wire, 100 yards long, that can be shaped into coils for magnets and other uses," stated IGC President Carl H. Rosner. Argonne said the method used will produce the highest current density ever recorded for a short length of high-temperature superconducting wire in the U.S.—164,000 amps per square cm. at 452 F below zero. DOE will provide $1 million to Argonne and $500,000 to IGC. IGC will contribute $500,000.

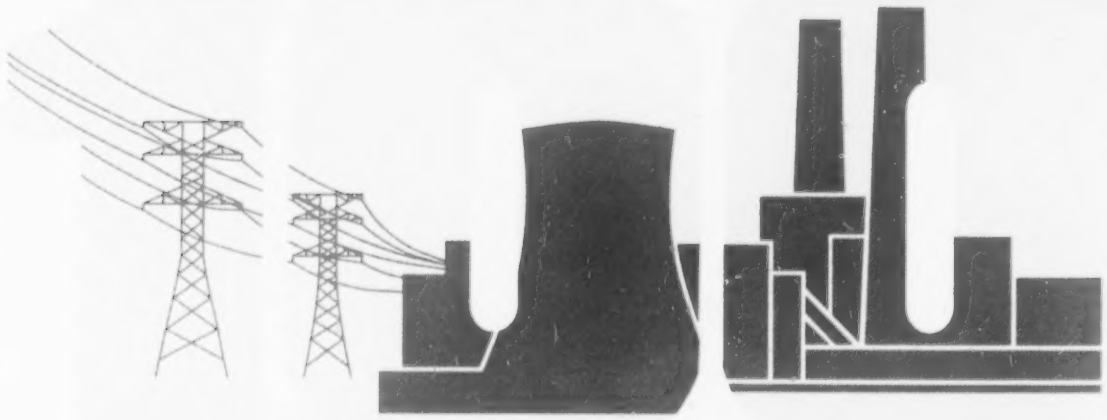
DOE to spend $50M on photovoltaic technology

The Department of Energy announced a $50-million, multi-year contract involving seven companies, to implement the second phase of the Photovoltaic Manufacturing Technology Initiative. The initiative, first announced in January 1990, is designed to overcome obstacles to improving photovoltaic manufacturing technology. DOE said the contracts will be cost shared, with DOE providing $30 million and industry contributing $20 million. The companies involved are: Astropower Inc., ECD Inc., Entech Inc., Mobil Solar, Siemens Solar Industries, Solarex Corp., and Utility Power Group Advanced Photovoltaic Industries.

Spanish utilities order replacement generators

Spanish utilities selected a new consortium formed by Framatome S.A. and Siemens AG to supply 12 replacement steam generators for four nuclear units at two plants. Central Nuclear de Almaraz and Asociacion Nuclear Asco selected the $237.5 million of components to be installed 1995-97 at Asco 1,2 and Almaraz 1,2. Three years of manufacturing will follow Siemens' design at Equipos Nucleares S.A., a Santander, Spain, company. The project is 60-percent local.

THE TOP 100 ELECTRIC UTILITIES



1992 FINANCIAL PERFORMANCES

Net income reverses 3-year slide

Mark T. Hoske
News Editor

Net income for the 100 largest investor-owned utilities increased 4-percent in 1991, stopping a three-year decline. The Top 100 also earned a record amount of revenue, gaining 4.5 percent over 1990. These gains came despite a slower, 1.1-percent gain in kilowatthour sales.

Less-adverse regulatory decisions, not-so-severe write-downs, and improved cost controls contributed to the improvements.

Table 1. Top 10 In Electric Customers

Rank '91	Rank '90	Company	Customers	% Change '90-91
1	1	Pacific Gas & Electric (C)	4,257,145	1.44
2	2	SCEcorp	4,078,559	1.16
3	3	Southern Company (H)	3,328,000	1.37
4	5	FPL Group (H)	3,263,370	1.72
5	4	Commonwealth Edison	3,249,178	0.96
6	6	Consolidated Edison (C)	2,943,283	0.22
7	7	American Electric Power (H)	2,774,398	1.00
8	8	Texas Utilities (H)	2,176,796	1.14
9	9	Detroit Edison	1,941,887	0.75
10	11	General Public Utilities (H)	1,878,688	0.86

Source: *EL&P* Top 100 Financial.

Top 100 sales data

Total sales for the Top 100 utilities in 1991 amounted to 2,358,559 GWh, up 1.1 percent from 2,332,991 GWh in 1990. Mild fall-winter weather and continued recession in many regions continued to slow sales growth. The Top 10 in sales ranked the same in 1991 as in 1990.

Over five years, 1986-91, total kilowatthour sales gained a total of 16.1 percent.

Average residential use was 9,378 kWh, up 2.9 percent from 9,118 kWh. The 1991 figure marks an all-time high for the Top 100 residential use, surpassing the previous record of 9358 kWh in 1988.

As usual, companies' with highest use were in regions with historically inexpensive hydropower and/or heavy concentrations of residential electric heat.

The average residential electric bill for the Top 100 would have been $62.75 in 1991, using the Edison Electric Institute 1991 average U.S. electricity price of 8.03 per kWh.

Customers, electric, gas

Total electric customers in 1991 numbered 84,272,415, up 1.3 percent from 83,187,704. Of the Top 100, 47 were combination utilities with both electric and natural gas service. The number of natural gas customers increased 2.1 percent to a total of 19,216,536.

Table 2. Top 10 in Electric Customers % Increase

Rank '91	Company	Customers	% Gain '90-91
1	UtiliCorp United (C)	402,135	56.30
2	Nevada Power	366,325	5.28
3	Central Louisiana Electric	211,332	4.74
4	Hawaiian Electric (H)	357,046	3.07
5	Puget Sound Power & Light	767,596	2.96
6	Central Vermont Public Service	141,972	2.92
7	Citizens Utilities (C	93,492	2.80
8	Portland General (H)	599,620	2.67
9	Sierra Pacific Power (C)	245,137	2.38
10	Pinnacle West Capital (H)	620,402	2.27

Source: *EL&P* Top 100 Financial.

Changes in the Top 10 for electric customers reflect demographic trends (table 1). Companies with territories that serve shrinking cities—such as Chicago, Detroit and New York City—gained less than 1 percent in electric customers. Like shifts in U.S. population, several utilities serving the South and West widened their leads.

The 10 fastest growing companies, in percentage increase of customers, was led by UtiliCorp, resulting from acquisition (table 2). Most other companies in table 2 represent faster growing areas of the country.

Revenue posts a new high

Revenue was $178.2 billion, a new high for Top 100 revenue, up 4.5 percent from $170.5 billion in 1990. Revenue includes electric, gas, and steam sales, and non-regulated businesses, where applicable.

Although FPL Group led Commonwealth Edison and Consolidated Edison in total electric customers, both Edisons outpaced FPL in revenue (table 3). ComEd and FPL flipped places in rank in the Top 10 from 1990 to 1991, as did PSE&G and AEP.

Table 3. Top 10 In Revenue

Rank '91	Rank '90	Company	Revenue ($ millions)	% Change '90-91
1	1	Pacific Gas & Electric (C)	9,778	3.25
2	2	Southern Company (H)	8,050	-0.04
3	3	SCEcorp	7,502	4.22
4	6	Commonwealth Edison	6,276	18.17
5	5	Consolidated Edison (C)	5,873	2.34
6	4	FPL Group (H)	5,249	3.23
7	8	Public Service Enterprise Group (H,C)	5,093	6.11
8	7	American Electric Power (H)	5,047	-2.53
9	9	Texas Utilities (H)	4,893	7.72
10	10	Houston Industries (H)	4,444	6.35

Source: *EL&P* Top 100 Financial.

Net income, earnings per share

Net income gained 4.0 percent to $15.0 billion, up from $14.4 billion. This reversed a three-year decline in net income, but was still below the record net income of $16.7 billion for the Top 100 of 1984. Continued cost-cutting efforts by utilities contributed to the improvement in 1991, along with fewer adverse rate decisions. Sixty-seven companies showed larger 1991 net income than in 1990. Also, eight companies showed net income losses in 1990, but only five did in 1991.

Average earnings per share (EPS) for the group was $2.00, up 4.7 percent from $1.91 in 1990. Sixty-two showed higher 1991 EPS than in 1990.

Utilities recovering from rough financial times or large write-offs led the pack in EPS gain (financial table). Some at the bottom showed a large one-

Continued on next page

Table 4. Top 10 Earnings Per Share

Rank '91	Rank '90	Company	Earnings Per Share $	% Change '90-91
1	4	Carolina Power & Light	4.53	3.90
2	3	Dominion Resources (H)	4.41	0.68
3	8	Pennsylvania Power & Light	4.01	1.52
4	5	LG&E Energy (H,C)	3.96	-10.44
5	9	Central Louisiana Electric	3.84	3.78
6	12	United Illuminating	3.67	3.38
7	18	Detroit Edison	3.64	11.66
8	10	Allegheny Power System (H)	3.61	0.00
9	14	San Diego Gas & Electric (C)	3.53	0.28
10	22	Atlantic Energy (H)	3.49	15.56

Source: *EL&P* Top 100 Financial.

1991 Electric Utility Sales

Company	Rank	Sales (kWh in millions)	90-91 % Change	86-91 % Change	Average Residential Use, kWh
Southern Company (H)	1	143,027	-1.42	1.05	11,659
American Electric Power (H)	2	112,639	-6.18	5.03	11,302
Texas Utilities (H)	3	82,358	-1.64	9.44	14,099
Commonwealth Edison	4	78,601	1.23	20.07	7,333
Pacific Gas & Electric (C)	5	74,196	0.19	19.99	6,421
SCEcorp	6	71,146	-0.65	10.82	6,060
Duke Power	7	69,887	2.66	15.49	12,710
FPL Group (H)	8	67,646	3.02	25.34	12,063
Entergy (H,C)	9	64,208	3.45	11.07	12,172
Houston Industries (H)	10	60,201	1.08	11.47	13,791
Dominion Resources (H)	11	58,501	6.80	17.80	12,772
Allegheny Power System (H)	12	54,545	-4.88	31.82	10,316
Central & South West (H)	13	51,775	3.52	13.10	11,413
PacifiCorp	14	51,021	2.67	105.66	10,464
Detroit Edison	15	46,583	-11.09	12.81	6,929
General Public Utilities (H)	16	43,141	1.95	22.38	8,374
Carolina Power & Light	17	40,995	3.03	14.72	12,472
Philadelphia Electric (C)	18	38,246	11.47	31.96	7,801
Public Service Enterprise Group (H,C)	19	37,849	3.07	13.67	6,304
Northern States Power (C)	20	37,425	2.29	26.32	8,001
Niagara Mohawk Power (C)	21	36,738	3.36	6.96	7,487
Pennsylvania Power & Light	22	36,219	1.45	18.02	10,101
Consolidated Edison (C)	23	35,890	1.17	18.97	4,116
Ohio Edison	24	31,713	-1.28	9.37	8,498
Union Electric (C)	25	31,610	3.83	11.87	11,106
CMS Energy (H,C)	26	30,692	3.44	9.70	7,289
Centerior Energy (H)	27	29,475	1.19	15.85	7,410
Northeast Utilities (H)	28	29,300	-1.05	6.41	8,286
Gulf States Utilities (C)	29	29,069	0.36	7.87	13,786
Florida Progress (H)	30	27,350	0.76	18.04	12,257
PSI Resources (H)	31	27,185	3.06	15.68	12,039
Baltimore Gas & Electric (C)	32	26,678	4.76	5.67	10,799
Wisconsin Energy (H)	33	25,016	5.75	31.99	8,067
Potomac Electric Power	34	24,796	3.61	19.43	11,163
New England Electric (H)	35	23,499	4.16	20.06	6,729
Oklahoma Gas & Electric	36	22,082	8.12	20.01	11,587
Cincinnati Gas & Electric (C)	37	21,013	-4.51	27.84	11,678
Public Service of Colorado (C)	38	20,452	1.51	14.08	6,563
Puget Sound Power & Light	39	20,183	3.12	24.45	13,217
Pinnacle West Capital (H)	40	19,986	1.06	44.17	10,941
Portland General (H)	41	19,654	-0.92	11.75	12,582
New York State Electric & Gas (C)	42	18,173	1.26	18.38	7,672
Southwestern Public Service	43	17,772	-2.24	7.95	8,377
Long Island Lighting (C)	44	16,411	0.16	12.12	7,812
SCANA (H,C)	45	15,755	-0.22	9.75	13,246
Illinois Power (C)	46	15,712	2.81	7.03	9,355
San Diego Gas & Electric (C)	47	14,888	-1.34	26.98	5,401
DQE (H)	48	14,840	9.73	17.73	6,331
KU Energy (H)	49	14,731	8.42	26.90	12,471
Boston Edison	50	14,139	-1.22	14.03	6,053
NIPSCO Industries (H,C)	51	13,679	2.64	22.83	7,591
Midwest Resources (H,C)	52	13,581	4.07	7.91	7,895
TECO Energy (H)	53	13,455	0.14	19.12	13,253
Idaho Power	54	13,358	3.07	-4.61	14,845
DPL (H,C)	55	13,315	5.44	5.81	11,213
Kansas City Power & Light	56	13,107	-4.98	5.39	9,959
IPALCO Enterprises (H)	57	12,246	2.51	12.00	11,460
LG&E Energy (H,C)	58	12,071	4.26	40.28	11,181
Delmarva Power & Light (C)	59	11,441	3.25	24.29	9,843
Washington Water Power (C)	60	10,577	-0.06	21.90	13,800
CIPSCO (H,C)	61	10,408	-3.06	11.42	9,904
Minnesota Power (C)	62	10,001	-2.63	34.47	8,450
IES Industries (H,C)	63	9,982	8.95	17.36	8,555
WPL Holdings (H,C)	64	9,969	4.66	14.39	9,015
Montana Power (C)	65	9,769	10.40	15.18	8,808
Wisconsin Public Service (C)	66	9,508	3.02	23.10	7,845
Nevada Power	67	9,552	3.58	42.37	13,107
KPL Gas Service (C)	68	9,538	4.48	11.66	9,616
Central Maine Power	69	9,106	-1.16	11.90	6,751
Kansas Gas & Electric	70	8,657	-3.14	14.25	10,219
Public Service of New Mexico (C)	71	8,231	14.83	22.34	6,139
Hawaiian Electric (H)	72	8,154	2.33	20.72	7,427
Tucson Electric Power	73	7,984	-0.02	24.86	8,534
Atlantic Energy (H)	74	7,936	2.31	21.70	8,440
Rochester Gas & Electric (C)	75	7,474	-3.07	11.53	7,015
Commonwealth Energy System (H,C)	76	7,368	7.16	22.88	8,181
UtiliCorp United (C)	77	7,072	16.39	146.67	9,708
Iowa-Illinois Gas & Electric (C)	78	6,487	0.41	-5.96	7,404
TNP Enterprises (H)	79	6,416	-0.06	-0.91	11,584
Eastern Utilities Associates (H)	80	6,180	5.62	32.50	6,177
Sierra Pacific Power (C)	81	5,929	2.35	47.72	7,452
Central Louisiana Electric	82	5,758	2.15	12.26	12,974
Central Hudson Gas & Electric (C)	83	5,740	0.90	15.87	6,933
Southern Indiana Gas & Electric (C)	84	5,721	2.96	28.31	12,256
CILCORP (H,C)	85	5,628	6.27	15.95	10,052
United Illuminating	86	5,234	0.57	6.54	6,756
Interstate Power (C)	87	4,803	6.17	23.48	8,145
Orange & Rockland Utilities (C)	88	4,230	4.34	23.36	7,286
Otter Tail Power	89	3,817	7.52	19.82	10,497
Empire District Electric	90	3,234	-0.34	10.85	11,437
Central Vermont Public Service	91	3,175	10.98	19.88	7,647
Madison Gas & Electric (C)	92	2,367	4.41	20.79	6,960
MDU Resources Group (H,C)	93	2,209	4.90	18.31	8,017
Green Mountain Power	94	2,190	-6.67	24.58	8,306
Bangor Hydro-Electric	95	1,566	-1.91	11.33	6,292
St Joseph Light & Power (C)	96	1,394	4.31	21.66	10,600
Citizens Utilities (C)	97	1,347	5.06	41.29	7,068
Northwestern Public Service (C)	98	1,071	3.38	18.94	8,853
UNITIL (H)	99	861	-0.81	-0.92	7,124
Upper Peninsula Energy (H)	100	787	1.39	5.04	6,117

(H) = Holding company (C) = Combination electric & natural gas utility Source: *EL&P* 27th Annual Top 100 Financial Survey.

time gain in 1990. Net income percentage change showed similar results.

While companies among the highest in earnings per share (table 4) represent some traditionally solid utilities, this measure depends somewhat on internal company policy. EPS relies partly on the number of common shares outstanding. For example, Central & South West might have been included in the Top 10 in EPS were it not for a two-for-one stock split.

Price per share

The price per average common share had a 1991 high of $32.31, and an average annual low of $24.24 (no data for TNP, Interstate, or UNITIL).

Of the total 1991 sales of 2,358,559 GWh:

- Residential sales accounted for 686,352 GWh, or 29.1 percent.
- Commercial sales, 609,372 GWh, 25.8 percent.
- Industrial sales, 689,264 GWh, 29.2 percent.
- All other sales, 373,572 GWh, 15.8 percent.

This sales mix was nearly unchanged from 1990.

Holding companies

Forty-one out of the Top 100 had a holding company structure, although most operate under guidelines that allow an exemption from the strict rules of the Public Utility Holding Company Act of 1935. Legislation is being considered to revise PUHCA.

Improvements in this year's results might anticipate a more competitive industry that legislation might create and prepare the Top 100 for the next baseload construction cycle.

Watch for the *EL&P* Top 100 Operating report in September.

Comparisons, 1990-91

In the tables and text, Top 100 data from 1986, 1990, and 1991 represent the same companies. Comparisons to data from previous *EL&P* Top 100 reports had a slightly different base of companies, primarily due to mergers and acquisitions. Multiple-year trends provide a general look at the industry's top investor-owned companies.

El Paso Electric and Public Service Co. of New Hampshire represent two of the largest differences. EPE, in Chapter 11 proceedings, could not provide figures in time to be included in this year's report.

Public Service Co. New Hampshire, with pending merger with Northeast Utilities, could not provide complete information so was not given a partial listing this year, as it was last year. PSNH, if ranked, would have been 60th in sales at 11,377 GWh. If NU acquisition is successful, it could boost NU from 28th to 16th in 1992 sales.

Notes to tables

The largest companies in total kilowatthour sales have made up *EL&P*'s Top 100 over the past 27 years.

1992 FINANCIAL PERFORMANCES

Regulators increasingly have provided incentives to promote efficiency. While this has slowed demand growth in some areas, it cannot, with present investment, replace the need for new baseload generation.

Offsetting greater investments in efficiency are growth of environmentally beneficial electric technologies. In some applications, electricity can be the best choice to replace other, less clean, forms of energy.

Given these opposing trends, *EL&P* continues to use total electric sales to determine the Top 100.

Some of the more significant financial footnotes follow, especially certain one-time changes. See individual company results for detailed explanations.

Alphabetically, by utility:

CMS Energy, despite a loss in EPS, showed a significant percentage gain over an even greater loss in 1990.

Eastern Utilities Associates rebounded from a 1990 write-off and loss from a subsidiary.

FPL Group's large percentage gain reflected a 1990 loss due to a charge for deposition of certain subsidiaries.

Gulf States showed higher results after a 1990 EPS loss.

KU Energy figures reflected formation of holding company in 1991.

LG&E Energy's lower earnings per share resulted in part from an accounting change in 1990.

New England Electric System showed a one-time increase in 1990 results related to Seabrook.

Public Service Co. of New Mexico posted a gain from a 1990 loss.

SCANA 1990 results showed a one-time gain from a property sale.

Sierra Pacific showed lower 1990 results due to an abandoned project.

Southern Company posted a five-year EPS high of $3.11 in 1986.

Pinnacle West 1991 results showed the costs of discontinued operations and charges related to Palo Verde.

Washington Water Power acquired a gas property in 1991.

Name changes, more on Top 100

KPL Gas Service applied for a name change to Western Resources, after completing purchase of KG&E in April. Kentucky Utilities formed a holding company, KU Energy. Southern California Edison is reported under its parent, SCEcorp.

With mergers and acquisitions, the Top 100 has come to include more operating companies. The corporate structure of the Top 100 now represents approximately 150 utility entities. A breakdown is available on "*EL&P* Electric Power Generation and Transmission Systems Map of the U.S.," from PennWell Maps; call (800) 752-9764.

EL&P's Top 100 data will be available on disk for further analysis; call (800) 345-4618 for more information.

EL&P's *Dianne Wilson and Judy Sisk helped gather data for this report from more than 100 U.S. investor-owned utilities.*

1991 Utility Financial Performance

Company	Revenues ($1000)	Net Income ($1000)	% Change in Net Income	Earnings Per Share,$	% Change in Earnings Per Share	Rank
Sierra Pacific Power (C)	468,766	41,946	435.85	1.75	400.00	1
Niagara Mohawk Power (C)	3,382,518	159,406	292.84	1.49	396.67	2
Philadelphia Electric (C)	3,975,837	468,576	278.28	2.15	270.69	3
Public Service of New Mexico (C)	857,168	13,486	241.07	0.32	239.13	4
Delmarva Power & Light (C)	844,807	83,981	3.92	1.69	181.67	5
Illinois Power (C)	1,474,905	78,378	167.96	1.04	167.97	6
FPL Group (H)	5,249,436	240,578	161.53	1.48	151.75	7
Gulf States Utilities (C)	1,702,235	102,283	330.98	0.34	134.34	8
Eastern Utilities Associates (H)	523,593	27,632	121.74	1.56	119.32	9
Southern Company (H)	8,050,000	984,000	36.86	2.78	45.56	10
CMS Energy (H,C)	2,940,949	(265,364)	48.63	-3.44	43.33	11
MDU Resources Group (H,C)	267,342	18,937	11.50	1.96	37.06	12
Nevada Power	538,775	35,176	40.75	1.05	34.62	13
Houston Industries (H)	4,443,739	417,383	22.96	3.28	22.85	14
TNP Enterprises (H)	441,343	18,455	21.92	2.23	21.20	15
Baltimore Gas & Electric (C)	2,352,720	253,426	18.87	2.51	19.52	16
Hawaiian Electric (H)	1,083,841	54,826	25.74	2.40	18.81	17
CILCORP (H,C)	590,165	40,484	11.39	3.14	16.73	18
Northern States Power (C)	2,201,158	206,053	16.22	3.29	16.25	19
Atlantic Energy (H)	777,970	102,046	28.07	3.49	15.56	20
Potomac Electric Power	1,552,066	197,866	23.95	1.87	15.43	21
Madison Gas & Electric (C)	232,200	24,880	12.94	2.28	11.76	22
Detroit Edison	3,591,537	535,205	11.67	3.64	11.66	23
DQE (H)	1,199,468	133,565	9.77	2.50	11.61	24
Wisconsin Public Service (C)	623,499	54,172	10.50	2.23	11.50	25
Interstate Power (C)	290,357	29,510	9.19	2.84	10.94	26
Montana Power (C)	938,934	105,715	11.30	2.03	10.33	27
CIPSCO (H,C)	722,081	77,461	8.53	2.11	9.90	28
Union Electric (C)	2,096,940	307,453	9.99	3.01	9.85	29
Northeast Utilities (H)	2,753,903	236,709	12.18	2.12	9.28	30
WPL Holdings (H,C)	648,801	64,934	9.06	2.43	8.97	31
Midwest Resources (H,C)	1,024,944	68,444	9.86	1.36	8.80	32
Duke Power	3,816,960	583,623	8.44	2.60	8.33	33
Central Maine Power	874,732	53,655	18.86	1.82	8.33	34
Entergy (H,C)	4,051,429	482,032	0.78	2.64	8.20	35
KU Energy (H)	587,660	80,587	8.03	2.13	8.12	36
Otter Tail Power	179,660	26,096	5.01	2.15	8.04	37
Upper Peninsula Energy (H)	60,475	4,454	8.05	2.96	7.25	38
NIPSCO Industries (H,C)	1,535,161	130,325	4.19	1.94	7.18	39
KPL Gas Service (C)	1,162,178	83,268	6.93	2.41	7.11	40
Green Mountain Power	143,555	9,604	12.39	2.45	6.99	41
Pacific Gas & Electric (C)	9,778,119	1,026,392	3.97	2.24	6.67	42
Citizens Utilities (C)	547,588	112,354	6.37	2.06	6.19	43
IPALCO Enterprises (H)	647,873	101,998	5.22	2.72	5.43	44
Central & South West (H)	3,048,000	375,000	5.34	1.99	5.29	45
UtiliCorp United (C)	1,075,200	73,500	24.79	2.23	4.69	46
Southern Indiana Gas & Electric (C)	326,490	37,232	2.26	3.16	4.64	47
TECO Energy (H)	1,154,078	145,300	4.26	2.55	4.08	48
Carolina Power & Light	2,685,755	364,380	0.74	4.53	3.90	49
Minnesota Power (C)	484,144	74,675	6.65	2.46	3.80	50
Central Louisiana Electric	337,338	44,929	5.61	3.84	3.78	51
United Illuminating	673,371	55,550	2.78	3.67	3.38	52
Puget Sound Power & Light	956,769	132,777	0.33	2.21	2.31	53
Central Vermont Public Service	233,469	18,576	5.96	2.48	2.06	54
American Electric Power (H)	5,046,611	497,935	0.31	2.70	1.95	55
Kansas City Power & Light	825,101	103,693	1.13	3.16	1.61	56
Pennsylvania Power & Light	2,557,874	348,414	1.31	4.01	1.52	57
Wisconsin Energy (H)	1,538,915	189,307	1.38	2.81	1.44	58
Central Hudson Gas & Electric (C)	494,736	42,941	4.64	2.40	0.84	59
Dominion Resources (H)	3,785,700	459,900	3.19	4.41	0.68	60
PacifiCorp	2,250,640	479,994	6.24	1.86	0.54	61
San Diego Gas & Electric (C)	1,789,012	197,525	0.28	3.53	0.28	62
Allegheny Power System (H)	2,282,167	212,575	1.27	3.61	0.00	63
Florida Progress (H)	2,074,700	172,100	4.43	3.20	-0.31	64
Public Service of Colorado (C)	1,794,904	137,459	2.81	2.48	-0.40	65
General Public Utilities (H)	3,371,599	275,682	-0.85	2.49	-0.80	66
Consolidated Edison (C)	5,873,058	566,910	-0.80	2.32	-0.85	67
St Joseph Light & Power (C)	89,580	9,790	-4.16	2.44	-1.61	68
Boston Edison	1,319,714	94,670	-0.81	1.96	-2.49	69
Oklahoma Gas & Electric	1,314,770	131,599	-3.75	3.27	-3.25	70
Southwestern Public Service	725,463	107,475	-3.66	2.63	-3.66	71
Ohio Edison	2,358,946	240,069	-5.50	1.60	-4.19	72
New York State Electric & Gas (C)	1,555,815	148,313	2.04	2.36	-4.84	73
Public Service Enterprise Group (H,C)	5,093,210	544,251	0.36	2.43	-5.08	74
Iowa-Illinois Gas & Electric (C)	512,537	54,367	-2.02	1.86	-6.53	75
Rochester Gas & Electric (C)	853,270	87,997	3.15	1.60	-6.96	76
Empire District Electric	150,441	18,768	-0.23	2.86	-8.33	77
Long Island Lighting (C)	2,548,850	239,144	-9.12	2.15	-8.90	78
Centerior Energy (H)	2,560,252	237,240	-10.29	1.71	-10.00	79
LG&E Energy (H,C)	714,965	82,951	-9.27	3.86	-10.04	80
SCEcorp	7,502,498	702,605	-10.65	3.21	-10.83	81
Orange & Rockland Utilities (C)	579,842	44,868	-9.97	3.12	-11.86	82
Bangor Hydro-Electric	146,508	6,585	-2.53	1.33	-12.50	83
UNITIL (H)	87,986	1,778	-13.69	2.48	-14.78	84
Kansas Gas & Electric	558,968	52,781	-16.70	1.70	-15.00	85
Northwestern Public Service (C)	122,900	14,445	-15.63	1.88	-15.70	86
Commonwealth Energy System (H,C)	849,568	18,120	-14.62	1.82	-15.74	87
Tucson Electric Power	589,285	(457,493)	-18.21	-18.10	-16.77	88
Idaho Power	483,193	57,872	-16.42	1.56	-18.32	89
Cincinnati Gas & Electric (C)	1,518,098	182,467	-14.16	3.32	-19.42	90
DPL (H,C)	1,005,491	128,951	-20.95	1.73	-22.42	91
Washington Water Power (C)	485,075	69,211	-3.15	2.68	-22.54	92
SCANA (H,C)	1,147,826	135,851	-25.19	3.37	-24.10	93
New England Electric (H)	2,094,378	179,810	-31.38	2.77	-32.60	94
IES Industries (H,C)	661,538	44,657	-44.41	1.85	-45.10	95
Commonwealth Edison	6,275,533	16,599	-63.75	0.08	-63.64	96
PSI Resources (H)	1,122,272	19,119	-83.99	0.35	-84.09	97
Texas Utilities (H)	4,893,173	(409,964)	-148.19	-1.98	-145.00	98
Portland General (H)	889,935	(49,867)	-149.89	-1.06	-148.85	99
Pinnacle West Capital (H)	1,474,550	(321,487)	-138.80	-2.15	-291.96	100

(H) = Holding company (C) = Combination electric & natural gas utility

Source: *EL&P* 27th Annual Top 100 Financial Survey.

Manufacturers, utilities, governments combine to market electric vehicles

Mark T. Hoske, News Editor

Electric utilities, auto manufacturers, federal, state and local governments, battery researchers and coordinating groups are producing results on bringing electric vehicles (EVs) to market along with the needed infrastructure.

Despite progress, severe limitations remain.

These limitations, amplified by the conservative, cautious nature of many of the players, become more acute as environmental deadlines for vehicles near and as 11 states and the District of Columbia consider adopting California and New York mandates for EV sales. Except for California, the states are in air-quality nonattainment areas of the Northeast.

California rules may expand widely

The mandates are controversial. New York environmental regulators adopted the California standard, but the state legislature may overturn it. Manufacturers say its unclear if enough demand or interest can be created. Mandates also increase costs, they say.

GM's sporty Impact seems to be the EV with the most mass appeal...and a commercial production date. Below, as battery technology improves, so will performance. Quickness and range are tradeoffs.

California requires zero and low-emissions vehicles to be sold as a percentage of total auto sales—by 1998, 2 percent of vehicles sold must be zero-emissions (only EVs now qualify); and by 2003, 10 percent. That would translate into 35,000 EVs on the road by '98 and a total of 400,000 by '03.

Benefits: cleaner air, off-peak sales

Many utilities have supported EV development for the environmental benefits and for adding off-peak sales. Edison Electric Institute says the average EV uses 1 kWh per mile, or 10 MWh per year, based on 10,000 miles travelled. If only 10 percent of off-peak supply were available for charging, 20 million EVs could be on the U.S. grid without adding generating capacity.

EEI claims EVs cut overall emissions by 95 percent compared to gasoline vehicles, based on the present mix of U.S. generating sources.

Daunting challenges ahead

However, with deadlines approaching, daunting challenges remain, including:

• *Batteries.* Battery technology, the largest single handicap for electric cars, has progressed slowly this century. Gasoline provides 100 times more work per weight than lead-acid batteries, a Department of Energy official noted recently. Lead-acid batteries only provide 20 times more work per weight than rubber bands, he added.

Given these limits, an EV battery array carries about as much energy as a gallon or two of gasoline, allowing 60-150 miles of travel, depending on the vehicle and use. A late model internal-combustion Ford Escort has a range of about 400 miles.

While technologies are advancing, batteries are still costly and require replacement, adding thousands of dollars to EV life-cyle costs. And it might be decades before away-from-home recharging is as hassle-free as gassing up.

• *Performance.* Acceleration of most EVs is still too slow for aggressive highway driving, particularly in urban California. Quicker acceleration is technically possible, but cuts range needed for many long California commutes.

• *Comfort.* The zero emissions rule requires electric heating and air conditioning. These rapidly decrease range. Some advances have been made. For example, Electric Power Research Institute has developed air conditioning that cuts range penalty of 45 percent to 11-26 percent.

• *Price.* EVs, from major manufacturers, aren't priced for everyone. Initial price for Chrysler TE-vans is expected to be $120,000 in December, although company officials said the price will fall. Vehma International refits GM's Vandura, a full-sized Chevy van. The resulting G-Van EV sells for about $53,000. EPRI contributed to development of both.

CO_2 Reductions Through Electricity Substitutions

Transportation Mode	Electric Counterparts CO_2 Reductions
Electric Vehicle vs. Gasoline Car	43% to 54%
Electric Train vs. Diesel Train	14.89%
Electric Trolley vs. Gasoline Bus	71.86%
Electric Trolley vs. Diesel Bus	58.52%
Electric Train vs. Large Semi-Trailer Gas Truck	46.39%

Source: Edison Electric Institute

This BMW four-passenger concept EV takes 15.6 seconds to get to 50 mph, but the range is 166 miles.

• *Uncertainty.* General Motors confirmed in late April that commercial production of its prototype "Impact" sports car EV would start by January 1995. Company representatives promise the production model of Impact will rival gasoline competitors in price and performance, but gave no details.

• *Infrastructure.* Various areas of government are working on standards for plugs, voltages, recharging, and related building, electrical, and highway codes. Infrastructure includes "fueling" facilities, standards, EV maintenance, and anything else required to make EVs as desirable to own as other vehicles. Manufacturers and industry groups warn that lack of standardization is slowing the process. Some utilities and others are working on creating convenient parking/recharging areas. Solar, metering, and distribution automation technologies also will be involved.

• *Process.* John Wallace, with Ford Motor Co.'s EV program, expressed frustration at getting all participants in the process to work quickly, saying it's like "trying to get all the elephants to dance." With government, automakers, utilities, and others involved, "No one wants to make a mistake," he added. Pending legislation should help, if passed.

• *Market.* Given limitations, who's going to buy one of these? By mandating sales, rather than availability, California has guaranteed EVs will be on the road, even if automakers have to sell them for much less than manufacturing costs.

Making a market with mandates

The EV market and mandates were some of the items industry leaders discussed at the Electric Vehicle Seminar, Washington, DC, sponsored by the Electric Transportation Council and Edison Electric Institute on April 28.

Some market clearly exists, according to a recent survey for Southern California Edison. More than half of 1000 respondents favored the mandated-sales law; about half of those opposing it said they'd change their mind if tax breaks were attached to EV purchases.

Michael Peevey, Southern California Edison president, speaking at the ETC-EEI conference, gave the results of the survey. Of people saying they would purchase an EV, two-thirds said that $1000 annual costs for battery replacement wouldn't stop them.

"You can mandate all the sales you want," said J. Michael Davis of DOE, "but somebody's got to want to buy them." Davis is assistant secretary of conservation and renewable energy at the Department of Energy.

Watch for more on electric vehicle developments in future issues.

This G-Van, owned by Lower Colorado River Authority, is one of about 150 manufactured. It's often at industry shows, but with 60-mile range, and $53,000 current price, the G-Van's market seems limited.

HENRY STEIN, Senior Editor-Power Production

Vibration monitoring proves itself at Clinton Power Station

Ronald L. Stiemsma
Illinois Power Co.

During the last four years, a comprehensive vibration monitoring system has been developed at Clinton Power Station. This program now includes over 204 machines and has documented over $480,000 in cost savings during its first year of implemention. The machines in the program include motors, pumps, fans, gearboxes, and diesel engines ranging in size from 5 to 6000 hp.

Before the new program began, Clinton collected some vibration data. It consisted of recordings of overall vibration data on one point of a machine. The data then was trended manually. But this technique provided no diagnostic capability and was unsuccessful in predicting many failures.

Current program

The current vibration program uses a portable data collector, a host computer, and trending/analysis software. The system's initial cost was approximately $40,000, but the investment was paid for in less than one year of service.

The largest saving in the first year came after a seal failure on a 6300-hp recirculating water pump. An analysis and monitoring program convinced the Nuclear Regulatory Commission to allow the 985-MW reactor to be brought back online two days earlier than would have been possible without the program. Savings came from the engineering and repair personnel efforts that were no longer needed for the task and the unit's beginning to earn from generation again.

Another large saving was estimated from replacing bearings that had not yet failed on a 75-hp fan. According to the analysis, bearing failure was imminent and would have damaged the fan severely.

Clinton personnel collect vibration data at each accessible bearing location in both the horizontal and vertical directions. Axial data also is taken on each of the machine components—both the driver and driven units—for every machine in the program.

Besides trending vibration data, the program also trends other system parameters—discharge/suction pressure, motor current, etc. This has helped to identify problems that were system-related rather than a fault of the machine.

The first step in developing the vibration program was selecting the machines to be monitored. Engineers selected 32 machines for the pilot program. These were units critical to plant operation or that had a history of problems. By starting with only 32 machines, the engineeers were able to learn the many aspects of vibration monitoring without being overwhelmed by the data collection task.

This methodology also allowed for the most important and time-consuming aspect of developing the program, the initial research into the internal parts of the machines selected.

What data to collect

Some of the other data that needs to be investigated before any vibration data is collected are the number of blades on the fan or impeller, number of teeth on gears, running speeds of the machine components, and types and characteristics of the bearings (i.e., ball diameter, number of balls, pitch diameter, and contact angle). Some of this data is available from the machine manufacturers, but some is not available until a machine is inspected.

However, opening up a machine to find this information is not recommended. So, in some instances, best engineering judgement was used to fill in the missing information.

With all the information gathered, personnel began to develop the database and customize it to each machine. Although this is time-consuming, it saved many hours when performing analysis of the vibration data.

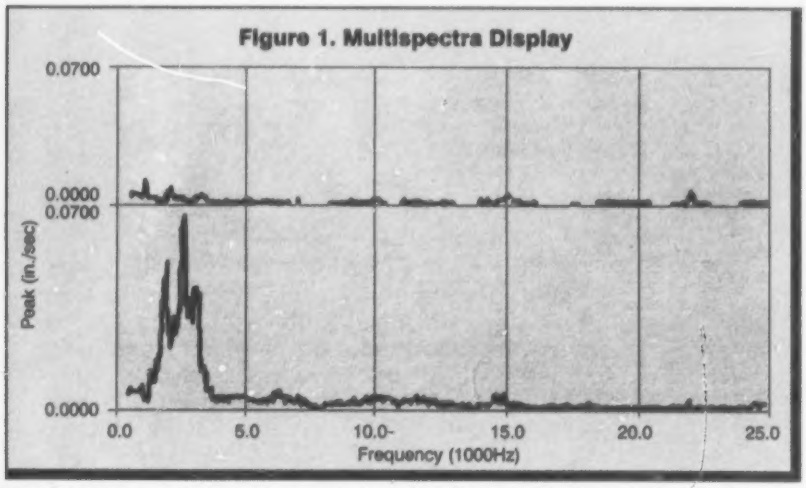
Bearing substitutions

One of the biggest problems encountered was that when a bearing needs to be replaced, it is not always replaced with the same model as the original. Many bearing manufacturers have cross references for "equivalent bearings." These bearings are equivalent in handling the design intent, but may have different physical characteristics, such as the number of balls.

These differences can completely alter the vibration signature coming from a bad bearing in the machine. Personnel at Clinton now document the type bearing installed during corrective maintenance.

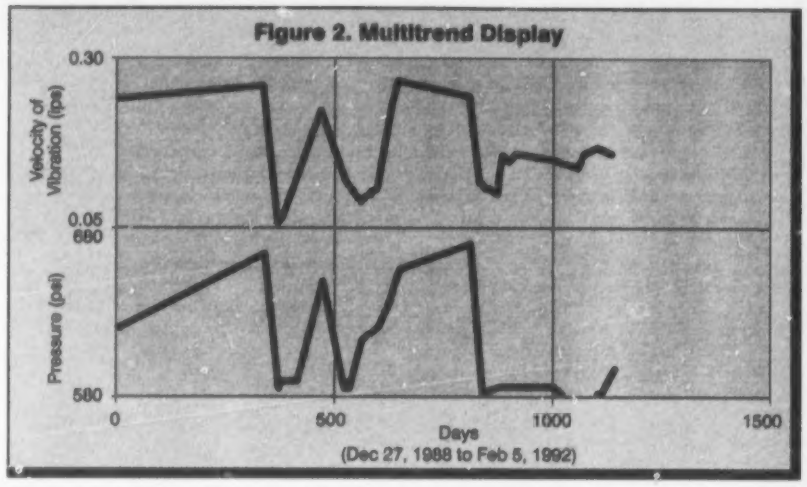
An analysis and monitoring program convinced the NRC to allow the reactor back online two days earlier than it would have without the program.

Figure 1. Multispectra Display



Graph shows the same data point on a vertical pump. The two sets of data were taken within 15 min of each other. Although there appears to be a bearing problem with this pump, the cause of the variation was the controller on the discharge valve that allowed the valve to close.

Figure 2. Multitrend Display



These curves show the clear relationship between axial pump vibration and pump discharge pressure. They indicate the importance of knowing system parameters when vibration data is collected.

Everyone adds their ideas

Engineers involved the station's maintenance group early in the program and received their support.

Although this was essential for success, it produced a problem that nearly overwhelmed the project. The maintenance group flooded the engineers with requests for assistance on many machines not scheduled to be in the program.

The requests doubled the size of the pilot program in two weeks. Because of the growth, initial research into many machines could not be done, which made the analysis much more difficult.

However, the growth also allowed the vibration program to have a greater chance of success. After starting work on the original 32 machines, with the majority in generally good condition, the implementation group was able to help diagnose many suspected problems on the additional units. Some of them were specified by maintenenace workers with comments such as, "It sounds funny." In many of these cases, however, work could be cancelled based on acceptable vibration data.

Costs vs. benefits

A cost/benefit analysis was performed after the first and second years of the program, and showed significant savings obtained. In the third year, the program did not expand much, and the majority of the monitored machines ran well. Therefore, savings were relatively small.

Although it was difficult to provide dollar amounts for "work saved" by replacing a bearing before it actually failed, maintenance history was used from similar machines that actually had failed, and these dollar amounts were used.

Comparisons showed a considerable savings from work that was cancelled based on satisfactory vibration data. To date, machines which had work cancelled due to the program have run with no problems.

New features

Process changes can greatly affect the overall vibration levels of a machine in that process (Figs. 1 and 2).

So, in the last year, Clinton added the ability to trend bearing cap temperatures along with vibration. This is done by using an infrared temperature sensor and entering the data obtained into the datalogger while collecting vibration data.

The engineers also are investigating combining the oil analysis and vibration databases to improve analysis capabilities.

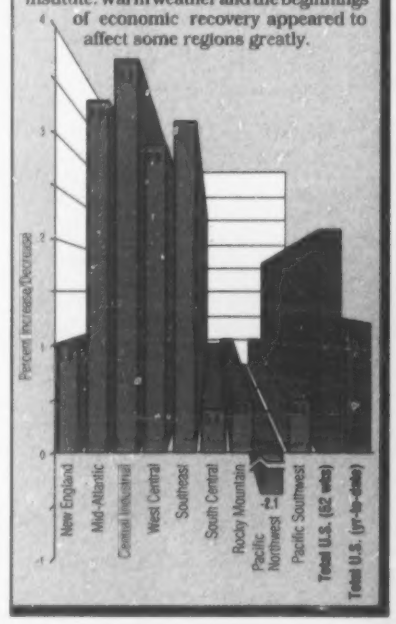
Future plans

Plans for 1992 include the collection of more useful diagnostic information. Some of this additional data will be more process information, such as pressures and temperatures. Also, an overhaul plan is to be established that is even more dependent on predictive maintenance.

Engineers are working with the vibration equipment supplier to develop a smaller datalogger that could be used by area operators while they are making their rounds. They would collect local system parameters on the datalogger and download this information into a database that is similar to and communicates with the vibration database.

ELECTRIC OUTPUT
Growth Mixed

Changes in net electric output from the Mainland U.S. electric utilities continued to vary widely for the 52 weeks ending April 25, as reported by Edison Electric Institute. Warm weather and the beginnings of economic recovery appeared to affect some regions greatly.



In-duct Ca sorbents remove more SO_2 with fabric filter than with ESP

PALO ALTO, CA—In pilot-scale testing, duct injection of calcium-based sorbents upstream of a fabric filter yielded higher SO_2 removal rates than injection ahead of an electrostatic precipitator (ESP).

The Electric Power Research Institute reported that proof-of-concept tests at its Arapahoe Test Facility in Denver of dry-injection pilot-scale tests were performed with a 2000-cfm fabric filter, a 4000-cfm fabric filter, a 4000-cfm electrostatic precipitator, and EPRI's own HYPAS (hybrid pollution abatement system).

The tests assessed effects on SO_2 capture of sorbent type, approach-to-adiabatic-saturation temperature, calcium-to-sulfur ratio, inlet SO_2 concentration, steam injection, sorbent injection upstream of humidification, recycling sorbent, and residence time. Researchers looked into performance of 15 sorbents, including commercial calcitic hydrates, dolomitic hydrates, and specially prepared calcitic hydrates with a silica-enhanced sorbent.

Results and reasons

The better results obtained with the fabric filter were ascribed to increased gas/solid contact provided by the filter material.

The primary variables affecting SO_2 removal in both ESP and fabric filters were approach-to-adiabatic-saturation temperature, calcium-to-sulfur ratio, and rate of steam injection.

Gas volume flow was 2500-5000 cfm and its velocity was 1.8-3.6 fps. SO_2 concentration was 900-3000 ppm.

Using commercial calcium hydroxide, a 20°F approach-to-adiabatic-saturation temperature, and calcium-to-sulfur ratio of 2.0, SO_2 removal rates ranged from 34 to 42 percent for injection ahead of an ESP and 40 to 60 percent for injection ahead of a fabric filter. At a 40°F approach-to-adiabatic-saturation temperature and holding the other parameters constant, the results were SO_2 removal rates of 25-35 percent for the ESP and 30-38 percent for the fabric filter. The upper values in both sets of tests were obtained with 350-pph steam injection.

The HYPAS removal rates were the same as those from the baghouse configuration. However, HYPAs significantly reduced deposition of ash and sorbent in the vicinity of the humidification atomizers and the sorbent injection point. This characteristic allowed for more reliable operation at low approaches to adiabatic saturation temperatures where the duct injection process was most efficient.

Parameters that had little or no effect on SO_2 removal rates were initial SO_2 concentration, method of steam injection, and type of sorbent.

Basic concepts

In the basic process, a calcium-based sorbent is injected into the flue gas downstream of the boiler air heater, but upstream of the particulate control device. The sorbent removes SO_2 while it is in suspension in the ductwork, as well as while in suspension in the particulate collector.

Reaction byproducts and flyash are collected in the particulate control device—the electrostatic precipitator or fabric filter.

Moisture is injected upstream of the particulate control device to increase the humidity of the flue gas, a prerequisite for substantial SO_2 removal.

The ESP used is a three-field, masted frame design with a specific collection area of 450 ft^2/1000 cfm. The baghouse is a single-compartment unit containing 64 bags with an effective filtering area of 662 ft^2 and an air-to-cloth ratio of 3.0.

HYPAS concept

The HYPAS process uses a second

Continued on page 33

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